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Skip-Row Planting Patterns Stabilize Corn Grain Yields in the Central Great Plains

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Abstract

The highly variable climate of the central Great Plains makes dryland corn (*Zea mays*) production a risky enterprise. Twenty-three field trials were conducted across the central Great Plains from 2004 through 2006 to quantify the effect of various skip-row planting patterns and plant populations on grain yield in dryland corn production. A significant planting pattern by plant population interaction was observed at only one of 23 trials, suggesting that planting pattern recommendations can be made largely irrespective of plant population. In trials where skip-row planting patterns resulted in increased grain yields compared to the standard planting pattern treatment (every row planted using a 30-inch row spacing), the mean grain yield for the standard planting treatment was 44 bu/acre. In those trials where skip-row planting resulted in decreased grain yield compared to the standard planting pattern, the mean yield was 135 bu/acre. The plant two rows, skip two rows planting pattern is recommended for risk-averse growers in the central Great Plains where field history or predictions suggest likely grain yields of 75 bu/acre or less. Planting one row and skipping one row is recommended for growers with moderate risk-aversion and likely yield levels of 100 bu/acre or less.

Introduction

The central Great Plains is a temperate semi-arid region with large variations in total annual rainfall from year to year (8). Most of the highly variable annual precipitation is received during the months of May, June, and July. Unfortunately, high temperatures and low relative humidity occur at the same time, resulting in high evaporation and transpiration potential. Extended periods of drought are common. Consequently, dryland (rainfed) production of full-season summer crops such as corn is a risky enterprise, i.e., the range of possible grain yields is large and unpredictable (5).

In southeast Queensland, a subtropical semi-arid region, skip-row planting patterns yielded as much or more sorghum (*Sorghum bicolor*) grain as the standard planting pattern (every row planted using a 39-inch row spacing) when yield levels were below 41 bu/acre (7). They concluded that skip-row planting promoted grain yield through the conservation of soil water stored between the widely spaced crop rows for use by the crop after anthesis. Corn grown using skip-row planting and limited furrow irrigation in Texas effectively depleted soil water 75 cm laterally from the planted row between tasseling and the end of the growing season, but had less ability to extract soil water 113 cm from the row, which was the center of the skipped area in a plant two rows, skip two rows planting pattern (6).

Computer simulations using long-term historical weather data for southern Queensland and northern New South Wales showed that with skip-row planting patterns, total crop failure of sorghum did not occur; however, skip-row planting reduced high-end yield potential of sorghum compared to the standard planting pattern (9). This agreed with field studies conducted in the Texas High Plains that found grain sorghum biomass and leaf area index were reduced in 60-inch rows compared to 30-inch rows in all three years, and grain yield considerably reduced during favorable growing seasons (4).

The introduction of glyphosate-resistant corn hybrids, increased use of no-till production methods, and higher corn grain prices have increased grower interest in dryland corn production in semi-arid portions of the central Great Plains. We proposed skip-row planting to help stabilize corn yields under semi-arid conditions. The objectives of this study were to examine the feasibility of incorporating skip-row planting into dryland corn production for improving drought tolerance and to identify the environments in which skip-row corn planting is justified.

Field Trials

Twenty-three field trials were conducted from 2004 through 2006 across Nebraska and into western Kansas and northeast Colorado. Soil characteristics and agronomic information for each site are provided in Tables 1 and 2, respectively. Glyphosate was applied one to three times for weed control in all trials except at Mead in 2004. Supplemental preemergence herbicides were used in some of the studies and included herbicides such as atrazine, acetochlor, alachlor, isoxaflutole, and S-metolachlor. Nitrogen fertilizer was applied in all studies based upon soil nitrate tests and expected yields, and ranged from 30 lb of N per acre at Scottsbluff and Sidney in 2005 to 180 lb of N per acre at Concord in 2004 and 2005.

All trials were factorial arrangements of four planting patterns and three plant populations in a randomized complete block experimental design with four replications of each treatment. Planting pattern treatments were: (i) the standard planting pattern, consisting of planting every row using a 30-inch row spacing; (ii) plant two rows and skip one row (P2S1); (iii) plant one row and skip one row (P1S1); and (iv) plant two rows and skip two rows (P2S2). Plant populations were selected to represent a broad range of recommended populations for an area (2,5). In eastern Nebraska, plant populations were 15,000, 22,500, and 30,000 plants/acre; in western Nebraska and Kansas, plant populations were 10,000, 15,000, and 20,000 plants/acre; and at Akron, CO, plant populations were 8,000, 12,000, and 16,000 plants/acre. Trials were dryland, except at Scottsbluff where two trials received supplemental irrigation prior to flowering. To achieve the same plant populations between plots, plant populations within planted rows were increased to compensate for skipped rows. With the exception of Tribune, KS, and Sidney, NE, where planting was at the desired populations, over-planting was followed by appropriate thinning by the V4 stage to achieve target populations.

Treatments were eight rows wide including skipped rows. The center two rows were harvested for grain yield. Plot lengths varied from 25 to 30 feet. Plots were harvested using plot combines, except at Concord and Mead, NE, where plots were hand-harvested. Grain yields were on a per land area basis with skipped rows included in calculations and grain weight was adjusted to 15.5% moisture content.

Table 1. Soil series and taxonomic suborders for trial locations.

Site[x]	Year	Soil series	Taxonomic suborders
Mead, NE	2004, 2005	Sharpsburg silty clay loam	Typic Argiudolls
Concord, NE	2004	Baltic silt loam	Vertic Endoaquolls
	2005	Thurman loamy sand	Udorthentic Haplustolls
Lincoln, NE	2004	Sharpsburg silty clay loam	Typic Argiudolls
Clay Center, NE	2004, 2005	Hastings silt loam	Udic Argiustolls
North Platte, NE	2004, 2005	Hall silt loam	Pachic Argiustolls
Hayes Center, NE	2004	Keith silt loam	Aridic Argiustolls
Trenton, NE	2005	Keith silt loam	Aridic Argiustolls
Colby, KS	2006	Keith silt loam	Aridic Argiulstolls
Ogallala, NE	2005	Vetal loamy fine sand	Pachic Argiustolls
Tribune, KS	2004, 2005, 2006	Richfield silt loam	Aridic Argiustolls
Alliance, NE	2005	Alliance silt loam	Aridic Argiustolls
Sidney, NE	2005	Alliance silt loam	Aridic Argiustolls
Akron, CO	2004, 2005	Weld loam	Aridic Argiulstolls
Scottsbluff, NE	2004, 2005[y]	Tripp fine sandy loam	Aridic Haplustolls

[x] Sites arranged geographically from east (96.9°W longitude) to west (103.7°W longitude), with annual precipitation generally decreasing and elevation generally increasing from east to west.

[y] Two trials were conducted at Scottsbluff, NE, in 2005; one received no irrigation and one received irrigation until flowering.

Table 2. Previous crop, planting date, corn hybrid, and harvest date for trial locations.

Site[x]	Year	Previous crop	Planting date	Corn hybrid	Harvest date
Mead, NE	2004	soybean	27 Apr	DKC 58-80 RR	28 Oct
	2005	soybean	27 Apr	DKC 58-80 RR	28 Sep
Concord, NE	2004	soybean	4 Jun	DKC 53-34 RR	3 Dec
	2005	corn	17 May	DKC 53-34 RR	8 Nov
Lincoln, NE	2004	soybean	4 May	DKC 58-80 RR	29 Sep
Clay Center, NE	2004	wheat	6 May	DKC 58-80 RR	28 Sep
	2005	wheat	9 May	DKC 58-80 RR	7 Oct
North Platte, NE	2004	wheat	12 May	DKC 53-34 RR	13 Oct
	2005	wheat	10 May	DKC 53-34 RR	17 Oct
Hayes Center, NE	2004	wheat	6 May	DKC 58-80 RR	29 Oct
Trenton, NE	2005	wheat	11 May	DKC 58-80 RR	18 Oct
Colby, KS	2006	wheat	28 Apr	Pioneer 35P10 RR	3 Oct
Ogallala, NE	2005	wheat	13 May	DKC 53-34 RR	21 Oct
Tribune, KS	2004	wheat	9 May	Pioneer 33B25 RR	20 Oct
	2005	wheat	6 May	Pioneer 33B54 RR	26 Sep
	2006	wheat	9 May	Pioneer 33B54 RR	14 Nov
Alliance, NE	2005	proso millet	12 May	Pioneer 38P03 RR	20 Oct
Sidney, NE	2005	wheat	16 May	DKC 42-95 RR	25 Oct
Akron, CO	2004	barley	25 May	Laser L45-F3 RR	17 Oct
	2005	wheat	24 May	Laser L45-F3 RR	13 Oct
Scottsbluff, NE	2004	sunflower	18 May	DKC 42-95 RR	22 Oct
	2005	proso millet	16 May	DKC 42-95 RR	25 Oct
	2005	dry bean	16 May	DKC 42-95 RR	25 Oct

[x] Sites arranged geographically from east (96.9°W longitude) to west (103.7°W longitude), with annual precipitation generally decreasing and elevation generally increasing from east to west.

Each trial was analyzed using PROC GLM (SAS Institute Inc., Cary, NC). Linear regression was used to compare the response of skip-row planting patterns to the standard planting pattern across trials.

With the exception of North Platte in 2005, there were no significant planting pattern by plant population treatment interactions, i.e., corn yield responded similarly to planting pattern across a likely range of plant populations used by growers in each location (Table 3). At North Platte in 2005, grain yields were greatest in the standard and P1S1 planting patterns and least in the P2S2 planting pattern across all three plant populations; however, the P2S1 pattern had an intermediate yield level at the middle and high plant populations, but was no different than the standard and P1S1 planting patterns at the lowest plant population.

Table 3. Statistical significance for planting pattern, plant population, and their interaction for trial locations.

Site[x]	Year	Planting pattern	Plant population	Pattern by population interaction
Mead, NE	2004	*	*	NS
	2005	*	*	NS
Concord, NE	2004	*	*	NS
	2005	*	NS	NS
Lincoln, NE	2004	NS	*	NS
Clay Center, NE	2004	NS	NS	NS
	2005	NS	*	NS
North Platte, NE	2004	NS	NS	NS
	2005	*	*	*
Hayes Center, NE	2004	*	NS	NS
Trenton, NE	2005	*	NS	NS
Colby, KS	2006	*	*	NS
Ogallala, NE	2005	*	NS	NS
Tribune, KS	2004	*	*	NS
	2005	NS	*	NS
	2006	NS	*	NS
Alliance, NE	2005	NS	*	NS
Sidney, NE	2005	NS	NS	NS
Akron, CO	2004	*	NS	NS
	2005	NS	NS	NS
Scottsbluff, NE	2004	*	*	NS
	2005	*	*	NS
	2005[y]	NS	*	NS

[x] Sites arranged geographically from east (96.9°W longitude) to west (103.7°W longitude), with annual precipitation generally decreasing and elevation generally increasing from east to west.

[y] Two trials were conducted at Scottsbluff, NE in 2005, this one received no irrigation and the other received irrigation until flowering.

Plant population had a significant effect on grain yield in 14 of the 23 trials (Table 3). The effect of plant population on grain yield varied among the 14 trials. The purpose of including various plant population treatments in this study was to understand how plant population interacted with planting pattern. The lack of significant interactions between planting pattern and plant population indicates that planting pattern recommendations may be made irrespective of plant population within the range of generally recommended plant populations.

Planting pattern affected grain yield in 13 of 23 trials (Table 3). At eight of the 13 trials, grain yield in at least P2S2, and sometimes additional skip-row treatments, was less than the yield in the standard planting pattern treatment. The mean yield of the standard planting pattern treatment at these eight trials was 135 bu/acre. At the remaining five of 13 trials, grain yield in at least P2S2 was greater, by an average of 19 bu/acre, than the yield of the standard planting pattern treatment. The mean yield of the standard planting pattern treatment at these five trials was 44 bu/acre. In the ten trials with no significant effect of planting pattern on grain yield, the mean yield of the standard planting pattern was 87 bu/acre.

No trial located east of 101°W longitude (Hayes Center, NE) benefitted from the use of skip-row planting patterns compared to the standard planting pattern. In five of the nine trials east of 101°W longitude, grain yield was reduced in at least P2S2 compared to the standard planting pattern. In the 14 trials located at or west of 101°W longitude, grain yields were increased in five trials by at least P2S2 compared to the standard planting pattern treatment. Grain yields were reduced in skip-row planting pattern treatments in three trials west of 101°W longitude; however, in two of these trials where skip-row planting patterns resulted in reduced grain yield compared to the standard planting pattern, supplemental irrigation was applied prior to flowering (Scottsbluff in 2004 and 2005).

Developing a Regional Recommendation for Skip-Row Planting

Relative yield of the various skip-row planting patterns compared to the standard planting pattern for each site was regressed over all 23 trials. In lower-yielding environments, skip-row planting patterns improved grain yield compared to the standard planting pattern (Fig. 1). These findings agreed with those found in Australia with grain sorghum (7). The points at which the regression lines crossed the no difference line (grain yield difference between skip-row planting pattern and the standard planting pattern = 0) were 74, 101, and 72 bu/acre, for P2S2, P1S1, and P2S1, respectively.

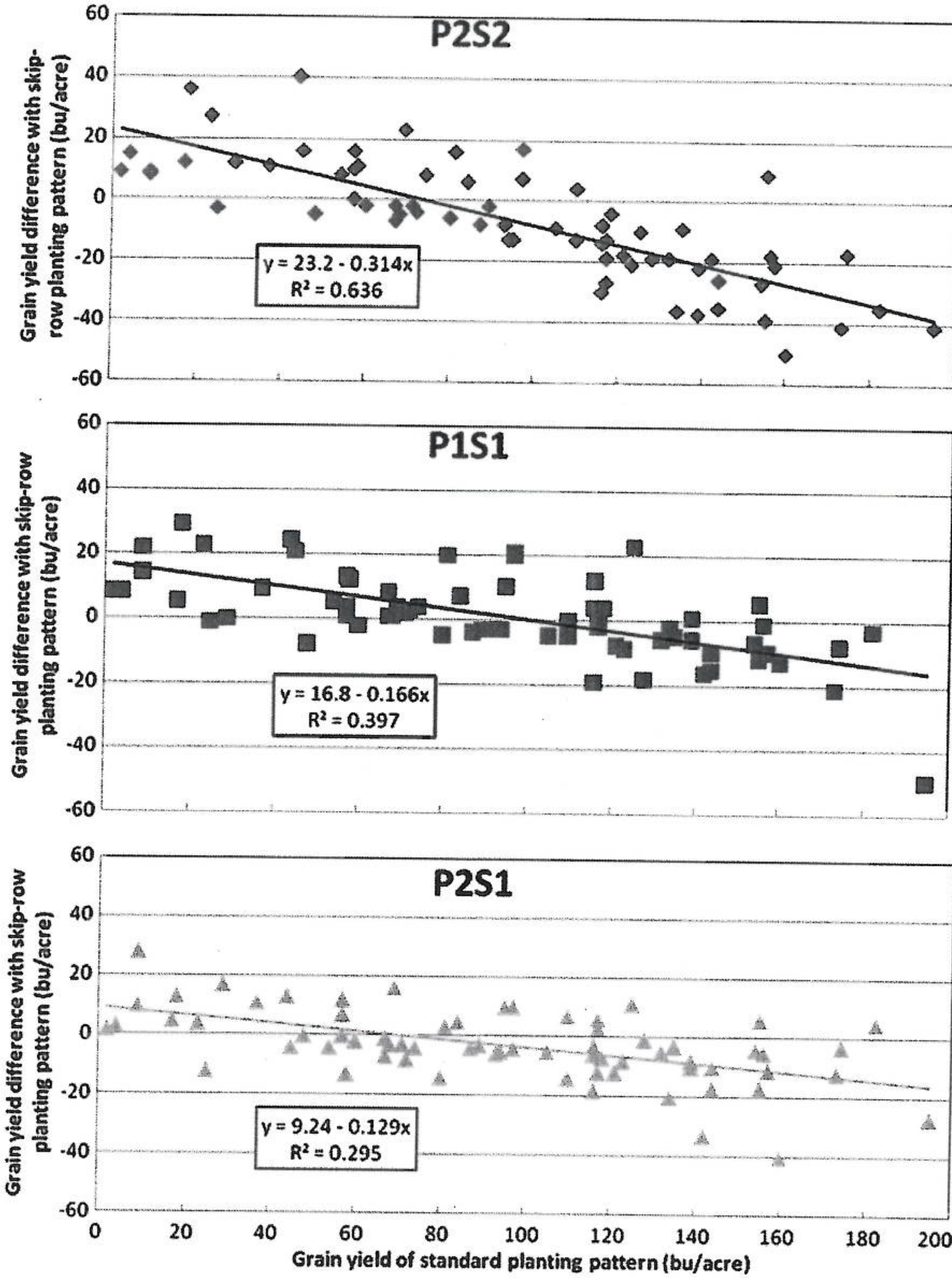

Fig. 1. Yield differences of skip-row planting patterns (P2S2 = plant two rows, skip two rows; P1S1 = plant one row, skip one row; and P2S1 = plant two rows, skip one row) relative to the standard planting pattern – 30-inch row spacing. All slope and intercept terms were significant at $P < 0.001$.

The regression equation slopes of -0.314, -0.166, and -0.129 for P2S2, P1S1, and P2S1 indicate that in lower-yielding environments, the gain from using P2S2 will likely be greater than for P1S1 or P2S1, but in higher-yielding environments, the probability and extent of loss relative to the standard planting pattern would be greater. The P2S1 treatment did not show a consistent ($R^2 = 0.295$) or substantial gain or loss in yields compared to the standard planting pattern. This was in contrast to the beneficial effects of P2S1 on sorghum in Australia (3) and Israel (1). The relation of grain yield gain and risk versus skip-row planting patterns reported here agreed with that reported for sorghum in Australia (9).

The range of grain yields for each planting pattern is one measure of risk or stability. The range of yields for P2S2, P1S1, P2S1, and the standard planting pattern were: 11 to 164, 10 to 179, 4 to 187, and 2 to 195 bu/acre, respectively. Median yields for these same treatments were: 90, 100, 93, and 96 bu/acre, respectively. These data support the regression analysis that indicates that skip-row planting patterns can be used to stabilize corn yields. They do so by reducing the frequency of very low yields, but also by decreasing the frequency of very high yields.

The benefits of skip-row planting patterns for stabilizing dryland corn grain yields should be considered by all dryland growers in the central Great Plains west of 101°W longitude. Risk-averse growers will see the greatest reduction in yield variability with P2S2, while growers with moderate risk-aversion may wish to consider P1S1. We recommend using P2S2 or P1S1 when grain yields are expected to be less than about 75 bu/acre. If yields are expected to fall between 75 and 100 bu/acre, growers may consider using P1S1. For areas with yield potentials of greater than 100 bu/acre, growers should use standard planting patterns. We did not see sufficient response to P2S1 to recommend its use instead of the standard planting pattern.

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